Wood Ash Experiments

South Bay 2000

by

M. Kalin, Boojum Research Limited

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TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

Wood Ash Experiments South Bay, 2000

Summary

The experimental use of wood ash produced by the Ear Fall saw mill as an amendment of tailings/rock mixtures along the Backfill raise ditch and on Mill pond was tested during growing season 2000. Very good growth was obtained with the addition of the material on the seeded plots. It's use as part of reclamation efforts appears of acid mine drainage sites appears dictated given the need for reusing/recycling wastes rather than landfill.

With this philosophy in mind the material was also used to test its effects of both Boomerang and Mud Lake. We have found that in the laboratory, in test containers and in enclosures in the lakes themselves, the wood ash has had a beneficial effect on lake water chemistry. The wood ash has increased PU and decreased metal acidity. However as a water treatment the application levels are relatively high as the particles sink quickly to the sediment. Its neutralization capacity in the sediments is being tested in lake. Based on short term experiments we would probably need to add between 430 to 860 tones of wood waste to Boomerang Lake, and/or additional 215 tones to Mud Lake to reach a water pH of 4.0. The long-term neutralization to the sediment is underdetermined yet. At these application levels we were concerned about effects on sediment and in turn the lake biota, especially the moss cover on the lake bottom. However at the lower end of these application rates, the plants appeared normal. At high application rates, the plants were detrimentally affected. Finally, the concentration of metals added by the wood waste is negligible compared to the metal content of both lakes. The test in Boomerang Lake enclosures to use the wood-ash as sediment amendment are ongoing and we hope we obtain permission to continue.

Introduction

Wood ash has been used extensively as a soil amendment in agriculture and silviculture [Ohno and Erich, 1990; Nkana et al., 1998; Hytonen and Kaunisto, 1999: Voundi et al., 1995; Kellner and Weibull, 1998; Hytonen, 1998; Tripepi et al., 1996; Silfverberg, 1991; Silfverberg, 1995; Clarholm, 1998; Bramryd and Fransman 1995; Zundel, 1994; Fritze et al., 1994; Huang et al., 1992; Silfverberg, 1998; Ray and Tomaszewski, 1957; Naylor and Schmidt, 1986. It is often added as a lime substitute, or in combination with lime or fertilizers.

The effect of wood ash on soil solutions, leachates, and groundwater appears to increase the alkalinity by providing cations (Ca, K, Mg, Mn) to the soils. There is some P in the wood, but this is tree species dependent. A number of studies have indicated that wood ash and P fertilizers should be used together, or depending on the amount in the wood ash alone. Most papers seem to have as a premise that nitrogen is abundant.

The primary cause of concern in using wood ash as a soil amendment is the heavy metal content of the ash. A number of studies, however, have suggested that cadmium, copper, mercury and magnesium are not released from the ash in any greater quantity than normal soils [Fritze et al., 2000; Parkman and Munthe, 1998; Lerner and Utzinger, 1956; Obemberger et al., 1997; Someshwar, 1996; Catricala et al., 1996; Williams, 1997; Zhan eta., 1996.

Experiments

Earlier this year Boojum Research was given permission to experiment with Ear Falls Mill wood ash as a soil conditioner and fertilizer on the South Bay mine site. Experimental plots were set up in the "now drained" Mill Pond, and on ditch slopes of the Backfill Raise.

In the Mill Pond experiment, plots were amended with fertilizer, fertilizer and wood ash, wood ash alone, and no amendment. Results were quite variable after one year. For example, when wood ash and fertilizer were added together, there was an 80% coverage of oats after 1 year. There was also a 50% survival of willow and poplar and about a 50% survival of cattails. Oat coverage increased from 30% in the controls, 40% in the fertilizer alone, 80% in the fertilizer and wood ash, and 70% in the wood ash alone. Overall, the wood ash and fertilizer and the wood ash alone gave more biomass than fertilizer alone.

Results from the BackFill Raise experimental plots are still being analyzed. However, our success with the materials in the Mill Pond area suggest that this material might be a good material for amending Boomerang and Mud Lakes sediment and water.

All of the studies cited in the introduction have looked at the effect of wood ash as a soil amendment. Some have looked at the leachate for heavy metals and have not found much to be bothersome. However, we have found no work which used wood ash as an amendment for water and sediment. There is no physical or chemical reason why the same results should not be forthcoming if used in water. Concerns over the dissolution of heavy metals in the amendments would not apply if wood ash were added to contaminated mining lakes and their sediment, as the metal content of the lakes is already many times that found in the ash. For example, for every cubic meter of wood ash that we would add to Boomerang Lake, we would be adding 2.3 g Cd, 28.4 g Cu, and 507 g Zn (assumes 0.86 kg/L wet weight; see Table I for concentrations of metals in the wood waste).

The questions we need to ask about the application' of wood ash to water are:

1) Does it work to reduce acidity and increase pH?

2) How much do we need to add to the lakes to reach the desired pH or acidity level?

3) How does the wood ash in large quantities affect the lakes biota (especially the benthic moss populations)?

4) Are there any detrimental environmental effects that might get through to Confederation Lake?

Table 1: Chemistry of Slurry Make from Wood Ash

Parameter (mg/L)	Wood Ash in DH_2O (20g in 100mL for 7days) (1:5) mg/L	Total [M] in wood ash $(ug/g)_{dry}$	Element-dissolved /Element-total (%)
Al *	8.1	1.9	2132
Ba	0.026	840	0.015
B	2.8	80	18
Cd	0.005	2.3	1
Ca	5.4	81100	0.03
Cr	0.058	4.8	6
Cu	0.021	33	0.32
Fe	0.17	6300	0.01
Mg	0.1	7100	0.007
Mn	0.019	3700	0.003
Mo	0.4	1.6	125
P	0.11	2500	0.02
K	1700	13400	63
Na	83	1700	24
S	-	480	-
Zn	0.065	590	0.1
NH_3-N	0.34	-	-
$(NO_2 + NO_3)$-N	3.6	-	-
TKN	1.6	-	-
pH	11.535	-	-
Em (mv)	-65	-	-
Cond (us/cm)	4996	-	-
Alkalinity	975.3	-	-

* likely incorrect analysis.

Answers:

Answer to Question 1: Does it work to reduce acidity and increase pH?

Yes, Ear Falls Mill wood waste does increase the alkalinity and increase pH of Boomerang Lake and Mud Lake water. The results of lab experiments are shown in Figure 1.

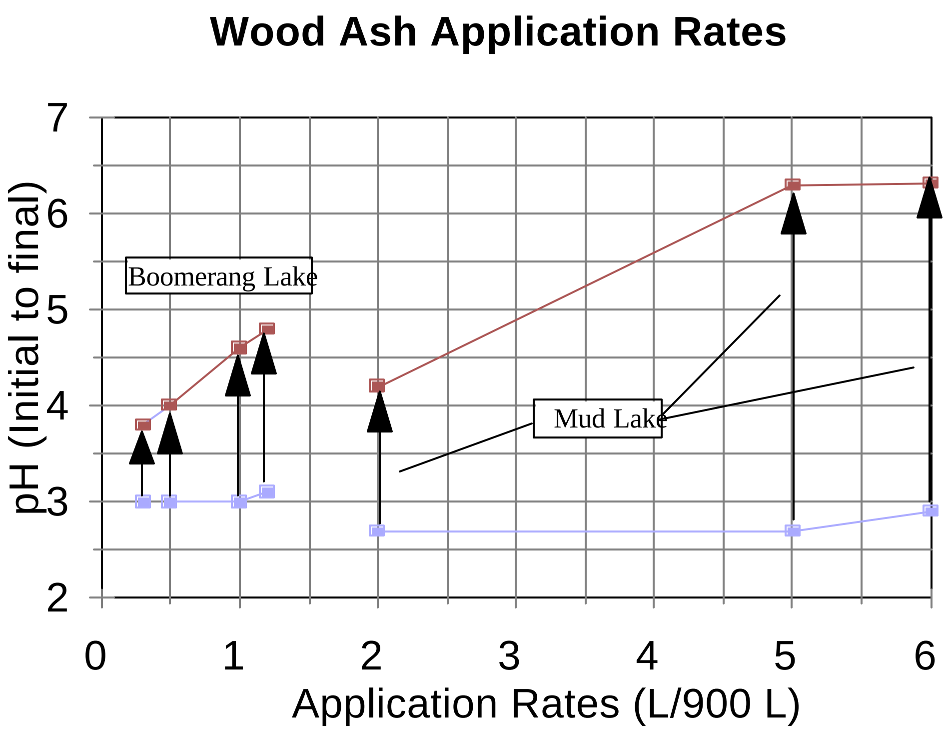

Figure 1: Application rates, together with initial pHs and pHs after 24-300 hours. If the experiment continued, pHs continue to climb

Boomerang Lake

When 1.2 L of wood ash (1.0kg) was added to 0.9 m3 of Boomerang Lake water, the pH slowly increased from 3.1 to 5.0 over a period of 2l hours.

?? When 0.5 L of wood ash (0.43 kg) was added to 0.9 m3 of Boomerang Lake water, the pH gradually rose from 3.0 to 4.0 after 215 hours. After 21 hours, the pH had climbed only to 3.3.

?? When 1.0 L of wood ash (0.86 kg) was added to 0.9 m3 of Boomerang Lake water, the pH gradually rose from 3.0 to 4.6 after 215 hours. After 21 hours, the pH had climbed only to 3.5.

Mud Lake

?? 6 L (5.2 kg) was added to 0.9 m3 Mud Lake, the pH increased from 2.9 to 5.7 after 48 hours. The pH continued to rise, so that after about 280 hours, the pH had risen to 6.3.

?? In a later experiment in the laboratory, utilizing a ratio equivalent to 2.0 L (1.7 kg) added to 0.9 m3 Mud Lake, the pH rose from an initial 2.7 to 3.0 after 21 hours, but kept increasing. After 1155 hours the pH had risen to 6.5.

?? Increasing the ratio of woodash to water to 5.0 L (4.3 kg) to 0.9 m3 Mud Lake, the pH rose from an initial 2.7 to 3.4 after 21 hours, but increased to 7.3 after 1155 hours.

The differences in reaction time to reach a certain pH are due to the different metal acidities in the different waters (ie. Iron in Mud Lake which is not present in Boomerang Lake).

From these experiments we can draw two conclusions. 1) Wood ash can treat Boomerang and Mud Lake waters. It reduces the acidity and increases pH. 2) Wood ash takes time to fully effect the water quality of the lake waters. After 21 hours, the full effects were not apparent (Table 2) as the pH had only rose to value o f5.0 when the samples for analysis were collected in the field tanks.

Na: not available (unfortunately at the time a Mud Lake water sample was forgotten to be collected). The analysis used for comparison is very similar, as Mud Lake did not change very much over the last year.

The wood ash treatment reduced Al, Fe, Zn and S as the pH increases. Na, Ca, and K increase as these are the reacting oxides presenting in the ash.

Answer to Question 2:

How much do we need to add to the lakes to reach the desired pH or acidity level?

It looks like from the results of the two above experiments that we need to add between 0.5 and 2.0 L of wet slurry wood ash to each cubic meter of Boomerang Lake water. This translates into between 500 cubic meters to 2000 cubic meters of wood waste to achieve pH 4 or between 430 and 1720 tones. Although, the best results are probably found at the low end when long term results with the interaction of the sediment have been obtained in 2001. We would need to add less than 2.0 L wet slurry to each cubic meter of Mud Lake, or less than 250 cubic meters (215 tones). The volume of Boomerang Lake is 1 million cubic m and that of Mud Lake 72,600 cubic meters.

One of the challenges of this application will be how to add the least amount of wood ash for the greatest benefit. Boojum Research has done further experiments in which we analyze the form of the wood ash being added. If the ash is added "as is", a great

Table 2: Comparison of Water Chemistry Before and After Wood Ash Treatment on Site

Mud Lake			Boomerang Lake			
Parameter	Landing	Middle	Landing	Landing	Landing	Landing
mg/L	Bef Woodash	Bef Woodash	Aft Woodash	Bef Woodash	Bef Woodash	Aft Woodash
pH	2.82	2.86	5.03	2.81	3.09	4.89
Cond us/cm	1750	1605	1192	960	1160	903
T ^{o}C	16.1	12.7	13.6	17.2	12.5	9.9
Acidity	410.7	na		202	na	
Lower Concentration following woodash treatment				Lower Concentration following woodash treatment		
Al	0.44	na	<0.005	6.2	na	3
Fe	79	na	8.7	7.7	na	1.1
Zn	16	na	7.6	34	na	32
S	280	na	190	160	na	150
Na				9	na	4.9
Higher Concentration following woodash treatment				Higher Concentration following woodash treatment		
Ca	150	na	180	95	na	110
K	5.5	na	32	4.1	na	17
Na	5.8	na	8.1		na	

deal of the ash agglomerates and settles to the bottom rapidly, producing little or no effect on the water column in the short term. If the ash is slurried first, and then added less of the agglomerates occurs, but there is still large particulate that settle rapidly. We then ground some of the slurry in a hand mortar and tested the dissolution rates again. There was very little difference in dissolution rates over more than 1000 hours of testing. While there may be more of a short-term effect of grinding, over the long-term the advantage disappears.

Answer to Question 3:

How does the wood ash in large quantities affect the lakes biota (especially the benthic moss populations)?

The biota of Boomerang Lake is predominantly periphyton and moss which now covers a substantial area of the lake bottom. This moss cover is important to the ecologicalstrategy for the lake. This cover prevents the sediments from being stirred up and keeps reducing conditions which prevents iron oxidation , which leads to pH depression. Along with stabilizing the sediments1 moss provide photosynthesis which increases the pH of the lake. The cover also removes dissolved metals, and provides a carbon source for organic sediments, which can further reduce metals to their mineral state.

Thus, we do not want to harm the moss cover of the lake. Some preliminary experiments done by Boojum in enclosures in Boomerang Lake suggest that application rates of 3.1 kg/rn3 the lower parts of the moss plants became bleached. This application rate, however, is 2-3 times the application rate envisioned for Boomerang Lake, but is simulating clumps settling to the bottom. At lower application rates (0.3 kg/m3), there seemed to be little shortAerm effect on the moss. The moss was harvested in the enclosure to simulate total destruction. In 2001, recovery will be monitored.

Answer to Question 4:

Are there any detrimental environmental effects that might get through to Confederation Lake?

The test applications of wood ash to the lake enclosures and to the cubic meter sized test containers showed that the material rapidly leaves the water column. The biggest challenge we would have in this regard would be to keep the material in the water column longer so that it would more efficiently increase pH. As the material settles rapidly in bucket experiments, no effects on the water clarity can be expected. Movement of the ash out of Boomerang Lake into Confederation Lake is a very remote possibility. Hence side effects of the potential use of this material on Confederation Lake are not expected.

The metal concentrations of the wood ash have concerned others (see introduction), but at the level of application which we are considering, the metal content of the wood ash, even if entirely dissolved, would not be measurable in Boomerang and Mud Lakes. Once we have discussed the potential of using this material with the Ministry we will carry out further assessments of the solubility of metals in the wood ash.

Recommendations

Boojum Research is impressed with the results that this material has on the water quality of Boomerang and Mud Lakes. We like the concept of using a material that is destined for the land fill, if not used. We like the idea that this is locally produced product and that it is inexpensive. Others have found that this material is a good soil amendment and metal leaching is not a problem. We would like to do further testing on this material, as application rates are important for a number of reasons. Several smaller doses of wood ash may bring up the pH of the lake over several months. This might be better than one large dose that quickly settles to the bottom and reacts with the moss cover. Boojum Research would like permission to test this material further with in-lake applications. We would also like to further test this material in sediments as a fertilizer source as well as an alkalinity generating material. We hope that you will grant us the permission to continue testing.

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